Integration of Discrete Event Simulation with an Automated Problem Identification

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Abstract— **Lean is one of the key tools for manufacturing organizations and service industry to survive in the competitive environment. Lean problem solving is one of the essential factor's to achieve the process of continuous improvement. The current research is adopting Lean Creative Problem Solving Techniques in measuring the effect of problems in production line performance measurements.**

The paper will first give an overview of the Lean Creative Problem Solving (CPS). It will, in addition discuss the research method in developing an automated problem identification. In other words, it will not only highlight where the problem is but will examine the main cause of the problem. The methodology was developed using simulation modeling technique.

Index Terms— **Automated Root Cause Analysis, Creative Problem Solving, Flow lines, Simulation Modeling.**

I. Introduction to Lean and Problem Solving

A. Introduction to Lean:

Lean Manufacturing (LM) is more than a set of tools and techniques. Lean Manufacturing includes the culture in which all employees continuously look for ways to improve processes, continuous improvement (Kaizen) [1]. It is a management philosophy and system of organizing to eliminate all non-value-added activities and/or waste throughput an organizations complete system. Essentially, "waste" is any activity that does not add value to the process of that the customer will not pay for. To make waste easier to identify, Taiichi Ohno has classified it in seven categories. The cost of major types of waste emerged as a tool to make operators understand and notice waste that was not previously obvious. In addition, it is a finite list, which is reassuring, since everything they do that doesn't fall into one of the seven types is not waste but useful work [2].

Ohno's seven types of waste are: over production, waiting, inventory or work in progress (WIP), over processing, transportation, over motion and making defective products.
The essential goal of lean manufacturing is to reduce the total lead time from receiving the customer order to dispatch of the goods. The results of time compression are greater productivity, shorter delivery times, lower cost, improved quality, and improved customer choices and satisfaction. As a result, the goal is to produce what is needed, at the time, with minimum materials, equipment, labor and space.

Implementation of lean processes requires the proper attitude. The change will require a total revolution in the culture of manufacturing operation, [3]. The change will include a complete understating of the process and highlight the different problems that may occur. This does not mean that every problem can be considered as a problem, but identifying the problems will help in improving the performance of the flow processing systems. But what is a problem and when is a problem is not a problem? The paper will illustrate the Lean Creative Problem Solving Process that will not only help in understanding the process but will improve the efficiency of the flow processing system. Problems occur mainly because of the different levels of variability among the workstations on the flow lines. Hence, it is very important to identify the relationship between proceeding and succeeding workstation, where root cause analyses will help.

Traditional flow processing systems are unable to efficiently operate with large amounts of product, process or demand variability. Such systems are designed to cope efficiently only within the conditions for which they were initially designed, i.e. typically they would be designed for stable demand, high and limited range in production volumes, limited variability in product mix ratios, limited range of processes, limited range of tooling, limited process route options, continuous production, and single products or a limited range of products that were similar in design.

The constraints of existing systems assume that variability in terms of operator task times and the occurrence of change-overs and equipment breakdowns will either have little effect on line efficiency or need only be considered at the subsequent operations planning stage and not at the flow line design stage.

B. Problem Solving:

Problem is an unwanted state or inefficiency in process that can be avoidable by filling information gap. [4] has defined the problem as "*A problem can be defined as any situation which is a perceived to exist between what is and what should be*". In other words, the problem is the gap between current and expected process state/output (Figure 1).

Problem solving is a systematic approach to fill process

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information gap or to achieve new state of process. According to [5], "*Problem solving is the art of finding way to get from where you are to where you want to be*". Many researchers have described problem solving approach in simple steps; Problem Identification, Problem Definition, Cause of Problem, Develop Feasible Solutions, Choose Best Solution and Implement.

There are many different problem solving methods in existence. Many of these methods are classified according to the levels of application i.e. individual [6], group [7] or organization [8].

The quality of problem solving and decision-making does not necessarily depend on the participants but the systematic manner in which the problem solving approach is carried out [9]. However most of the above approaches can be discussed into the K-T Method as it's designed to develop a more rational process. Once mastered, the ideas can never be forgotten. For the individual, group and organization, the application of these ideas means a better use of the resources and information at hand. According to K-T, problems are usually a result of "changes". However, not all changes cause problems, although there is only one change, simple or complex, which can produce the exact effect observed.

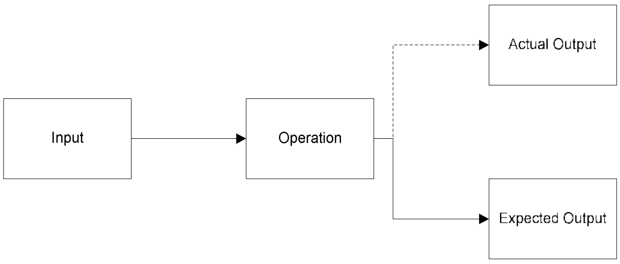

Figure 1 (Problem Definition)

II. LEAN CREATIVE PROBLEM SOLVING (CPS)

A. *Why use a problem solving process?*

It is very important to map the process in order to understand the full details of every activity. This understanding will not only highlight the value and non value activities but will help in identifying the main root cause of the problem i.e. the problem may be highlighted in one workstation but the main cause of the problem may be further up or down the flow lines.

B. *Methodology:*

Current research is based on mixed methodology. Hence, it gives you advantage of both *Qualitative and Quantitative methods*.

C. *The Lean Problem Solving Process:*

The research has used an existing model in Simulate; Discrete Event Simulation, to go through the Lean Creative Problem solving as identified in figure 2. The results were exported automatically to excel sheet. Results were correct according: a) total simulation time (12000min), specified frequency which was every two hours in that case (of 120min).

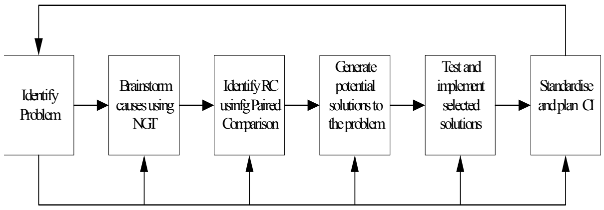

Figure 2 (Problem Solving Cycle)

Step 1 – Identify /Define the Problem i.e. using evidence from the assessment or obtained from other sources, write a problem definition – a concise statement of the results that are not being achieved and how the situation varies from the desired results. The problem definition is a statement of facts. It does not include any assumptions about the causes or the solutions in the problem definition.

One of the major pitfalls people get into is not defining the problem first. They get into teams and solve the wrong problem or argue because they are each solving a different problem. Here, an automated process mapping was created in excel to export the results from the DES model to highlight where is the problem;
The process mapping has highlighted that main problems lie in (Figure 3):

a) *High Waste,*
b) *Throughput rate does not match customer demand,*
c) *Shelf time- high (Queue Time),*
d) *and Waiting time high (Customer).*

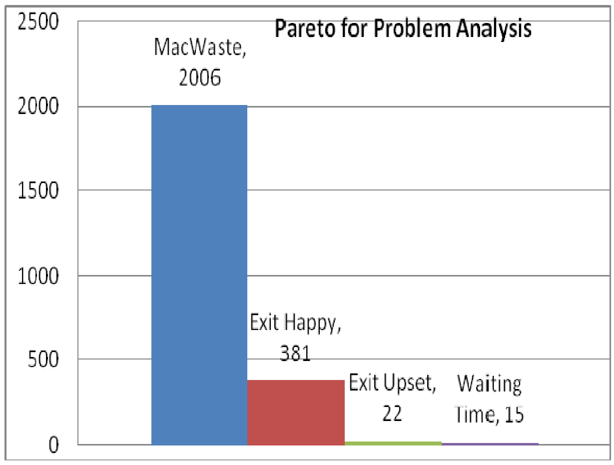

Figure 3 (Problem Identification)

Step 2 -Generate potential solutions – For most problems there are usually several solutions. The first idea is not always the best. Brainstorming and building on ideas are the most effective ways to find the right solution. This is a creative as well as practical step where every possible solution or variation is identified. The key at this stage is to focus everyone's efforts on analyzing the problem for the real cause. Sort out the difference between symptoms and the true causes.

By examining the results, brainstorming exercise was carried out to identify some potential solutions which are as follows (Table 1);

a) Reduce Operation Time,
b) Reduce Travelling Time,
c) Increase Self Life,
d) Minimise Waiting time,
e) Operator Flexibility (Cook Idle Time),
f) and Reduce Buffer Queue Time.

Step 3 Select and plan the solution – as the above main problems been identified. It can be seen that there are a wide variety of possible solutions. It is time to select the best solution to fix the problem given the circumstances, resources and other considerations. At this point the group is trying to see exactly what would work best given who they are, what they have to work with and any other considerations that will effect the solution i.e. money, time, people, procedures, policies, rules and so on. The research has used paired comparison to identify which best solution that can be tackled first.

Table 1 (Paired Comparison)

S. No.	Continuous Improvement Exercise	Vote Matrix					Totals		
1	Operation Time	2	3	1	1	6	1	2	13.33%
2	Travelling Time	3	2	2	6		2	3	20.00%
3	Self Life	3	3	6			3	4	26.67%
4	Waiting Time	4	6				4	1	6.67%
5	Flexibility (Cook Idle Time)	6					5	0	0.00%
6	Buffer Queue Time						6	5	33.33%
							Total		100.00%

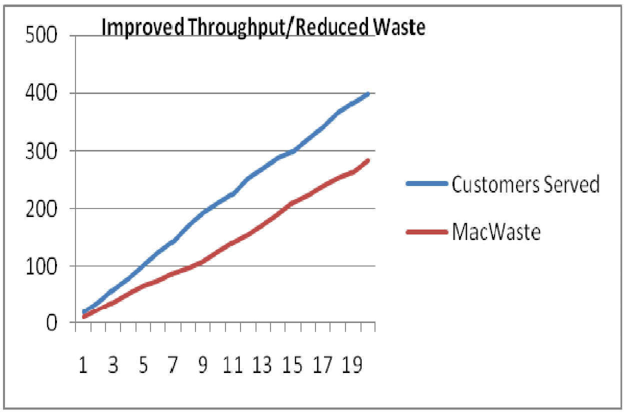

Figure 4(Test Results after implementation)

III. Future Work

A. Analyze the causes of the problem –

Now the problem has been defined, it needs to be analyzed to see what the real bottom line root cause is? Once the cause is found, plans can be made to fix it. Usually, there are several causes of a problem that require analyzing and prioritizing. This will require collecting data, which provides the facts needed, rather than opinions.

RCA is a process designed to facilitate the investigation of the fundamental or root causes for undesired outcomes e.g. problems, accidents, mistakes, and errors with a follow through to corrective action. Root cause analysis using the creative problem solving process (RCA-CPS) is a powerful, flexible and effective means of understanding any situation clearly, generating options and solutions and converting those options into practice.

RCA-CPS is particularly effective where the actual cause of a problem may not be immediately obvious. RCA-CPS helps practitioners avoid the complications of fixing the wrong problem, complicating a situation with an effective approach, or wasting time, money, goodwill, personal energy and other vital resources.

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